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Crystallization Characteristics of Metallocene Low Density Polyethylene/Low Density Polyethylene Blends

Kyung Ryong Kim, Jungwoo Han, and Ho-Jong Kang[†]

Center for Advanced Functional Polymers,

Department of Polymer Sci. & Eng., Dankook University, Seoul 140-714, Korea

[†]e-mail : hjkang@dankook.ac.kr

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: (m-LLDPE) Ziegler-Natta (LLDPE) induction time LLDPE/LDPE LLDPE m-LLDPE induction time LLDPE 가 가 induction time 가 LLDPE

ABSTRACT : The crystallization characteristics of metallocene linear low density polyethylene(m-LLDPE)/linear low density polyethylene(LLDPE) blends were investigated. The effect of blending on the induction time for crystallization, spherulites growth rate, and maximum size of spherulites was mainly considered in this study. The formation of separate crystal which is well known crystallization behavior in LLDPE/LDPE blend was not found in m-LLDPE/LLDPE blends. The blending m-LLDPE to LLDPE caused the dramatic decrease in the induction time of m-LLDPE/LLDPE blends but it seems that the blend composition shows less effect on the induction time. Lower branching number in m-LLDPE resulted in the increasing of spherulites growth rate and the maximum size of spherulites is depend upon both the induction time and spherulite growth rate of LLDPE component affected by m-LLDPE.

Keywords : metallocene low density polyethylene, blends, crystallization, branching number, induction time.

가
가
(LLDPE) 가 LLDPE tubular 가 20% LDPE
1,2 melt strength 가 3 extensional
(LDPE) melt flow 4 bubble 가

/

haze 가

LDPE melt strength 가 LDPE가 가
 long chain branching(LCB) . LCB
 chain entanglement 가
 hydrodynamic volume ,
 shear thinning 5,6
 LDPE 가 가
 LLDPE/LLDPE
 LLDPE LDPE
 7-9
 10
 11,12 가 가
 (m-LLDPE) LLDPE
 가 13,14
 Ziegler - Natta 가
 가
 12,15 가 LCB
 LLDPE/LLDPE
 LDPE가 가
 LDPE LCB m-LLDPE
 LLDPE 가
 가
 가 m-LLDPE/LLDPE
 m-LLDPE/LLDPE
 LLDPE m-LLDPE Dow Chemical
 Table 1 가 microphotograph

Table 1. Material Characteristics of Various Linear Low Density Polyethylene Used in This Study

	LLDPE	m-LLDPE (5400)	m-LLDPE (5100)
M_n	39600	45300	54000
M_w	192800	178700	184000
MWD	4.87	3.94	3.42
co-monomer branching number/1000 C	1-butene 17.87	1-octene 17.4	1-octene 15.2
wt%	6.9	12.6	11.1

branching Branching
 16 13 C NMR
 Hakke Rheomix 600p
 , 200 40 rpm 10
 m-LLDPE(5100, 5400)/LLDPE
 0/100, 25/75, 50/50,
 75/25 100/0
 m-LLDPE/LLDPE
 632.8
 nm He/Ne laser , detector
 576 x 384 pixel CCD detector
 cover glass
 가 30 mm
 hot stage , 112 - 116
 H_v pattern . pattern
 scattering vector q ,
 invariant Q_{Hv} induction
 time scattering
 angle (m) (R_{Hv})
 (G) (R_{Hv max})
 16
 Leitz
 Mettler hot stage (FP - 82HT)
 가 microphotograph

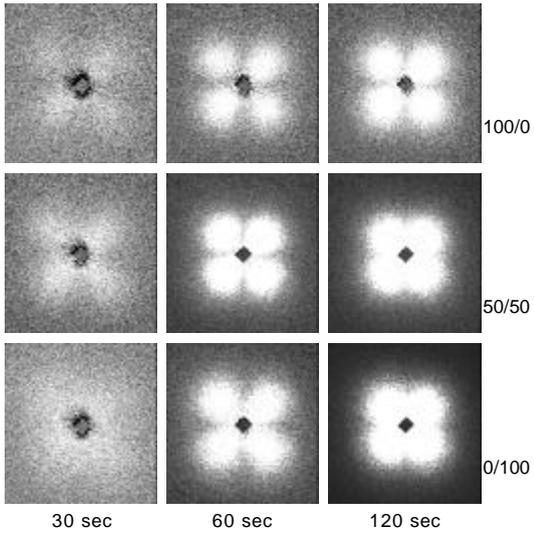


Figure 1. H_v light scattering patterns during the crystallization of m-LLDPE 5400/LLDPE blends at $T_c=116$.

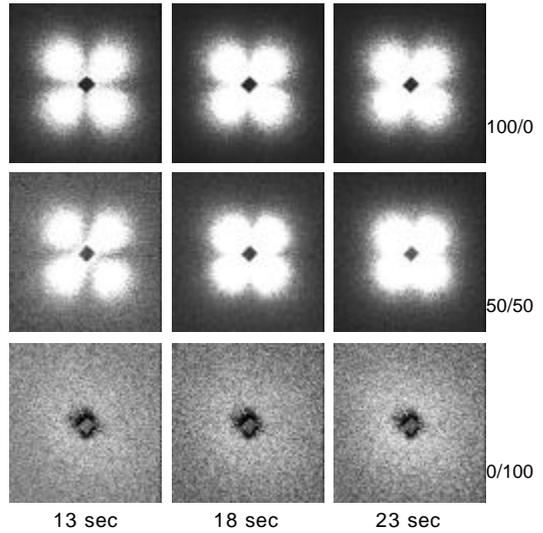


Figure 2. H_v light scattering patterns during the crystallization of m-LLDPE 5100/LLDPE blends at $T_c=116$.

Figure 1 2 m-LLDPE 5400/LLDPE m-LLDPE 5100/LLDPE 116 H_v pattern pattern

3 pattern

LLDPE 5400 LLDPE H_v pattern

branching m-LLDPE 5400 LLDPE octene butene LLDPE

가 long chain branching(LCB) 가 LLDPE LCB가

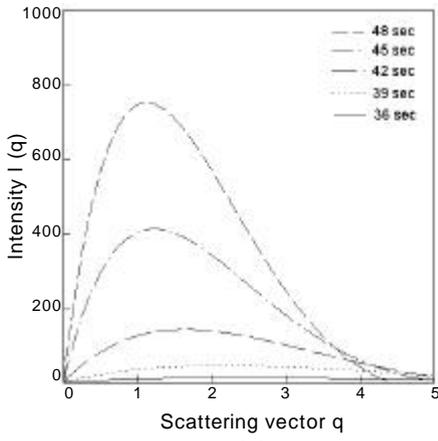
Figure 2

LLDPE 5400 m-LLDPE 5100
m-LLDPE 5400 H_v pattern
LLDPE branching 가 octene
LLDPE 가
가 , branching
branching
m-LLDPE 5400/LLDPE m-LLDPE
5100/LLDPE LLDPE m-LLDPE
LLDPE
m-LLDPE 5400/LLDPE
, Figure 1
m-LLDPE 5400
LLDPE
, m-LLDPE 5100/LLDPE m-LLDPE 5100
m-LLDPE /LLDPE

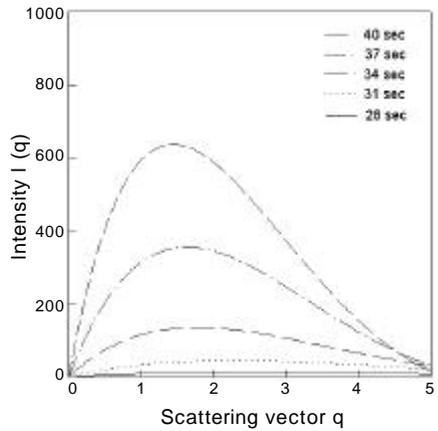
Figure 3

116 m-LLDPE 5400/LLDPE H_v
pattern 45° intensity scattering vector

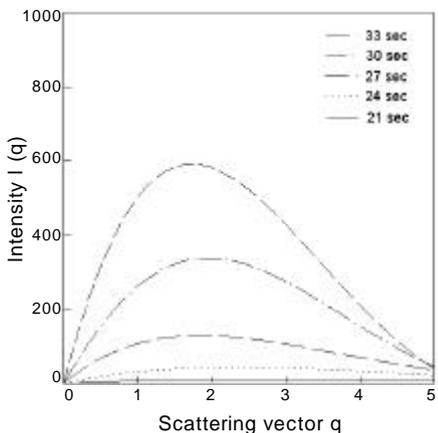
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(a)

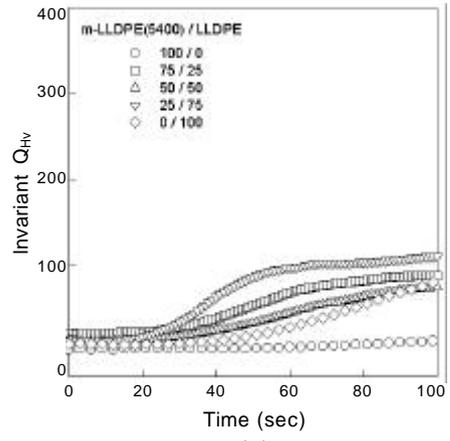


(b)

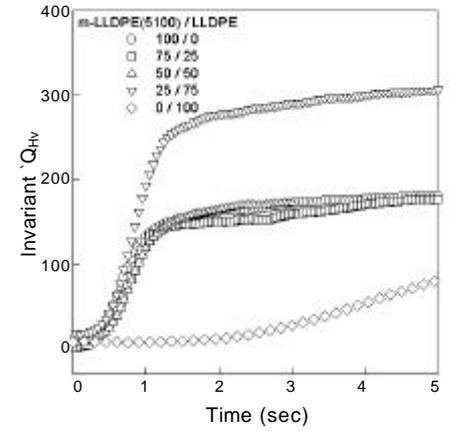


(c)

Figure 3. Scattering vector q vs intensity $I(q)$ for m-LLDPE 5400/LLDPE blends at $T_c=116$; (a) 100/0, (b) 50/50, and (c) 0/100.



(a)



(b)

Figure 4. Time variation of the invariant Q_{Hv} at $T_c=116$; (a) m-LLDPE 5400/LLDPE, and (b) m-LLDPE 5100/LLDPE.

Figure 3(b) shows the scattering intensity $I(q)$ versus scattering vector q for m-LLDPE 5400/LLDPE blends at $T_c=116$. The intensity peaks at $q \approx 1.5$ and increases with time. The legend indicates the time for each curve: 33 sec, 30 sec, 27 sec, 24 sec, and 21 sec.

Figure 4. Time variation of the invariant Q_{Hv} at $T_c=116$; (a) m-LLDPE 5400/LLDPE, and (b) m-LLDPE 5100/LLDPE.

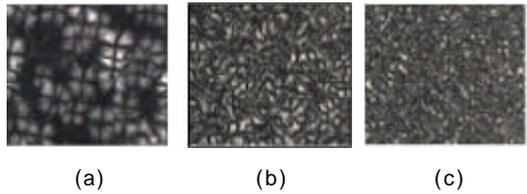


Figure 5. Polarized optical microphotography of m-LLDPE/LLDPE at $T_c = 114$ °C; (a) 100/0, (b) 50/50, and (c) 0/100.

invariant Q

가

invariant Q

Q 가

, Gibbs free energy (embryo) 가

(induction time)

LLDPE 5400/LLDPE

LLDPE

m-LLDPE

가 induction time

, m-LLDPE 5100/LLDPE

m-LLDPE 5100 induction

time

. M. Ree⁹ LLDPE/LDPE

LLDPE/LDPE

가

LLDPE가

가

LDPE LLDPE

domain

2

가

LLDPE

induction time

가

m-LLDPE/LLDPE

Figure 3

invariant Q

2

가

LLDPE/LDPE

LDPE

m-LLDPE

2

가

induction time

m-LLDPE/LLDPE

가

Figure 5

가

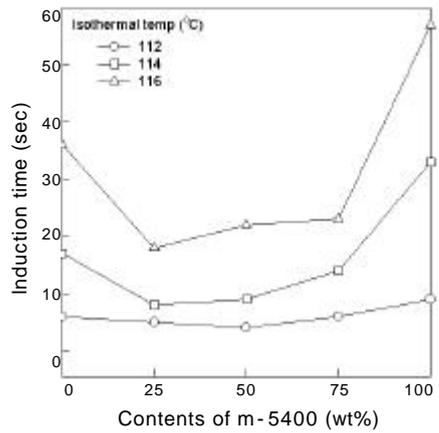
LLDPE/LDPE

LLDPE가

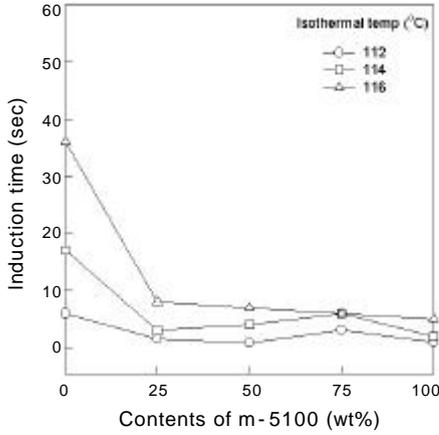
LDPE

가

8.9



(a)



(b)

Figure 6. Induction time as a function of m-LLDPE content at various temperatures; (a) m-LLDPE 5400/LLDPE and (b) m-LLDPE 5100/LLDPE.

m-LLDPE/LLDPE

m-LLDPE

LLDPE

time

m-LLDPE

induction

LLDPE/LDPE

LLDPE

branching

octene branching point가

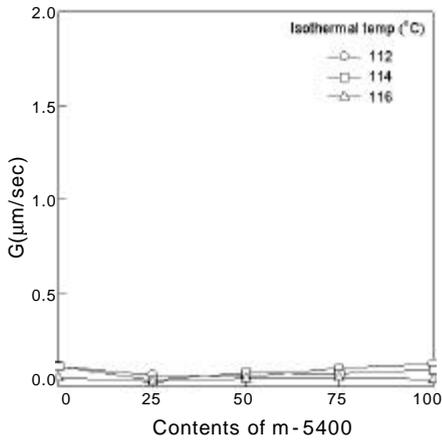
LLDPE component

Figure 6

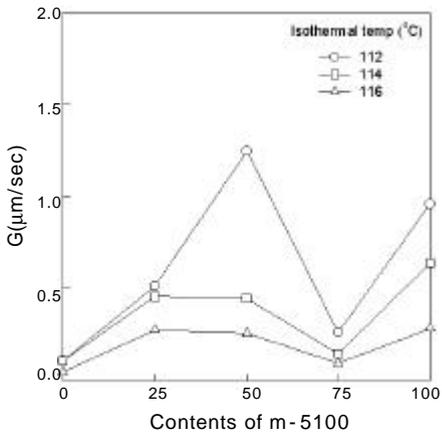
induction time

m-LLDPE

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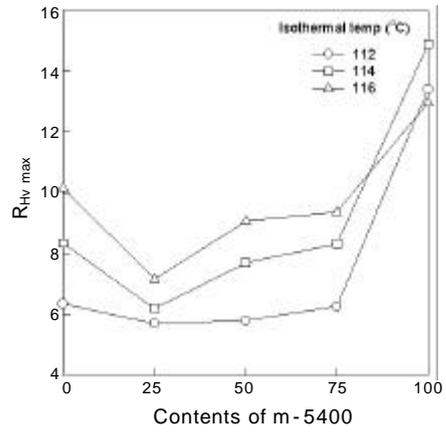


(a)

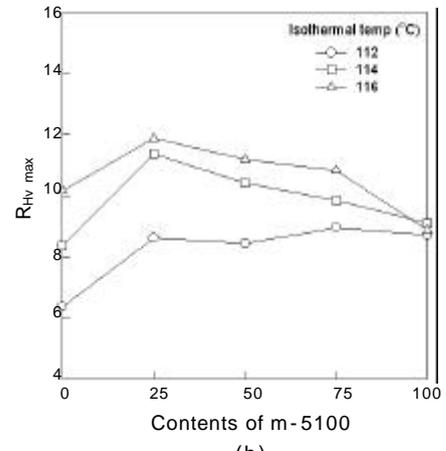


(b)

Figure 7. Temperature dependence of growth rate of the spherulite; (a)m-LLDPE 5400/LLDPE and (b)m-LLDPE 5100/LLDPE.



(a)



(b)

Figure 8. Temperature dependence of maximum R_{Hv} ; (a)m-LLDPE 5400/LLDPE and (b)m-LLDPE 5100/LLDPE.

induction time
 가
 induction time
 112
 energy 가
 m-LLDPE
 가
 induction time
 induction time
 가 LLDPE component
 max. scattering vector
 (R_{Hv})

G
 Figure 7
 16
 branching 가 branching
 m-LLDPE 5400 LLDPE
 가
 Figure 7 (b)
 branching 가 m-LLDPE 5100
 가
 m-LLDPE 5100/LLDPE
 m-LLDPE
 m-LLDPE 가 가

Figure 8

50/50
112
75/25
m-LLDPE/LLDPE
branching
가

m-LLDPE
가
가
branching
m-LLDPE

m-LLDPE LLDPE
induction time,
1. LLDPE m-LLDPE LLDPE/
LDPE
2. m-LLDPE
induction time
induction time
Induction time
가 , 112
가
3.
m-LLDPE branching
branching 가
4.
time induction
time
LLDPE
2000

Figure 8

m-LLDPE induction
time
LLDPE 5400 m-LLDPE 5100
5400
가
m-LLDPE/LLDPE
LLDPE , m-LLDPE LLDPE
가 LLDPE 가
가
가
m-LLDPE branching
LLDPE component
가 m-LLDPE 가
m-LLDPE 5400
가 가 m-
LLDPE 5100/LLDPE , m-LLDPE
5400/ LLDPE 가
m-LLDPE 가 가
가 가
m-LLDPE 5100
branching induction time
LLDPE 가 가 m-LLDPE
5100 가 가

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